Uncertain Supply Chain Management 13 (2025) 177–194

Contents lists available at GrowingScience

Uncertain Supply Chain Management

homepage: www.GrowingScience.com/uscm

Exploring the impact of blockchain technology, green supply chain, green practice, supply chain flexibility on green supply chain performance

Nelva Kirana Nurafindraningrum[a], Zeplin Jiwa Husada Tarigan[a*], Hotlan Siagian[a] and Ferry Jie[b]

[a]*School of Business and Management, Petra Christian University, East Java, Indonesia*
[b]*School of Business and Law, Edith Cowan University, Joondalup 6027, Australia*

A B S T R A C T

Article history:
Received May 1, 2024
Received in revised format May 29, 2024
Accepted July 12 2024
Available online
July 12 2024

Keywords:
Blockchain technology
Green supply chain
Green practice
Supply chain flexibility
Green supply chain performance

Changes are occurring in customers demanding that companies produce environmentally friendly products. Apart from that, there is pressure from the government so that companies carrying out business activities can follow the rules and regulations set. The company has developed a system that uses technology to support production process activities properly and adequately. Blockchain technology makes green supply chain implementation faster and more flexible to continue improving supply chain performance. Data is collected on companies implementing blockchain technology and environmentally friendly programs. Data was collected at 512 manufacturing companies in Indonesia using Google Forms, which was distributed via email and social media. Data analysis used PLS to answer all research hypotheses. The research results showed that blockchain technology significantly influenced green supply chain management of 0.816, green practice of 0.370, supply chain flexibility of 0.115, and green supply chain performance of 0.150. Green supply chain management is a commitment for companies that have become top management commitments to adopt by reducing consumption of materials that impact the environment, which affects green supply practices of 0.473, supply chain flexibility of 0.244, and green supply chain performance of 0.247. Green supply practice, as a form of company best practice application, can influence supply chain flexibility by 0.428 and green supply chain performance by 0.214. Supply chain flexibility that has been running in manufacturing companies has had a significant impact on green supply chain performances of 0.331. This research provides a practical contribution to top management's commitment to running a green supply chain to increase company performance. Contribution for regulators and rule makers to continue to carry out continuous monitoring of business actors. Theoretical contributions to enrich theories about the green environment, green supply chain management, and blockchain technology.

1. Introduction

Going green has received considerable attention, not only because of its environmental benefits but also because of its potential impact on business (Singh et al., 2021). 'Going green' involves adopting practices and technologies that prioritize sustainability, energy efficiency, and environmental responsibility (Fourie, 2012). Green consumption is an effort made to apply knowledge with practices that can lead to decisions and lifestyles that are more environmentally friendly and ecologically responsible (Allahham et al., 2024). The concern built by businesses can help protect the environment and maintain sustainable natural resources between generations, namely for the current and future generations, as a form of sustainable development (Esmaeilian et al., 2020). Businesses today have moved towards a green concept, and most companies focus on improving operational performance by reducing environmental pollution (Fantazy et al., 2018). The manufacturing industry has adopted the green concept in managing the supply chain to reduce the impact of damage or

* Corresponding author
E-mail address zeplin@petra.ac.id (Z. J. H. Tarigan)

ISSN 2291-6830 (Online) - ISSN 2291-6822 (Print)

doi: 10.5267/j.uscm.2024.7.006

pollution on the environment (Singh et al., 2021). Companies have paid a lot of attention to the impact of their business activities on the environment to reduce these negative impacts during supply chain activities (Sahoo & Vijayvargy, 2021). Going green in the manufacturing industry plays an important role in caring for the global environment (Wungkana et al., 2023). Manufacturing companies continue to maintain sustainable performance by increasing economic performance while maintaining adequate social and environmental performance (Saberi et al., 2019). The manufacturing industry maintains business sustainably while increasing its competitive advantage while paying attention to the ecological environment (Famiyeh et al., 2018). The manufacturing area environment has created clean air quality for operational processes (Sarkis et al., 2020). Manufacturing companies adopt environmentally friendly processes to reduce air pollution and harmful emissions (Wong et al., 2015).

Public awareness of using environmentally friendly products has increased over time (Fourie, 2012). The increasing number of consumer preferences for environmentally friendly products continues to increase. Consumers can make purchasing decisions based on the sustainability and environmental impact of the products used (Hartono et al., 2023). These changes in consumer behavior put pressure on manufacturing companies to adopt green practices to produce environmentally friendly products (Laari et al., 2018). The company always tries to maintain market share to maintain competitiveness compared to similar products. Consumers recommend using environmentally friendly products (Basana et al., 2022). Many consumers are worried about environmental conditions that must be maintained, so they demand that manufacturing companies immediately prepare environmentally friendly products (Tarigan et al., 2020). Global warming and environmental degradation have reached critical levels and are increasing awareness and urgency for sustainable solutions (Singh et al., 2021). Manufacturing companies are one of the main contributors to environmental pollution and, therefore, have an important role in reducing environmental problems (Fantazy et al., 2018). Manufacturing companies have adopted green practices and supply chains to reduce environmental impacts and contribute to a sustainable future (Saberi et al., 2019). Blockchain technology can balance product availability and demand realization to synchronize customers and suppliers (Meidute-Kavaliauskiene et al., 2021).

Blockchain is useful for transactions because it saves time and costs (Ghode et al., 2020). Companies try to carry out processes quickly and in an integrated manner so that coordination is easy, so they need to use adequate technology (Dubey et al., 2020). Companies can use technology effectively and efficiently and maintain their data security (Rejeb et al., 2020). Manufacturing companies can make company operations effective and efficient by using technology for knowledge sharing to innovate and produce products with strong competitiveness (Eidizadeh et al., 2020). Proper blockchain implementation for companies impacts customer trust with sustainable development (Esmaeilian et al., 2020). Blockchain applications are transformative for companies that can change transaction records well and are used jointly between functions within the company (Jain et al., 2021; Queiroz & Wamba, 2019). Blockchain has been introduced in the supply chain field to make supply chain flows more transparent, authentic, and trustworthy (Agi & Jha, 2022; Abeyratne & Monfared, 2016; Helo & Hao, 2019). Integrating blockchain into the supply chain can create a more reliable ecosystem (Choi, 2021; Kamble et al., 2019). Blockchain provides a record of transactions that cannot be changed or manipulated (Pattanayak et al., 2024). All product and delivery details are collected through various technologies and validated before becoming a permanent record in the blockchain (Cao et al., 2023). Blockchain technology provides superior economic and technological solutions because it can integrate decentralized data (Dutta et al., 2020; Sheel & Nath, 2019). Efficient implementation of global-scale transactions can eliminate intermediaries between various supply chain entities (Kummer et al., 2020). Blockchain technology has become an approach as a sustainable strategy to maintain its impact on the environment (Mubarik et al., 2019).

Blockchain technology is important for companies to develop competitive advantages by sharing information (Kuo et al., 2020; Lohmer & Lasch, 2020). Information sharing also plays a very important role in the context of the supply chain (Katsaliaki et al., 2022). Information owned by the company can be shared with partners to become a tool for good coordination and collaboration, and the information shared can become a competitive advantage for the company (Latunreng & Nasirin, 2019). The information obtained by the company can be communicated with suppliers, making it easier for both parties to control the procurement of quality materials promptly (Kouhizadeh & Sarkis, 2022). The information the company has can also be communicated to customers to help them produce the right product and have a delivery schedule (Latunreng & Nasirin, 2019). Companies can use existing information to develop strategies to produce competitive advantages (Eidizadeh et al., 2017). Green supply chain management that companies have established can adopt blockchain to maintain consistency in supply chain flows (Bag et al., 2021). Blockchain technology can impact companies' ability to carry out green supply chain management (Zhang et al., 2022). Blockchain implemented in companies can provide existing data along the supply chain so that it is transparent and distributed to existing components (Cao et al., 2023). The company's ability to obtain this information will impact on the speed of making decisions appropriate to operational conditions. Blockchain technology is closely related to the supply chain in producing efficient and effective products (Brau et al., 2023; Kummer et al., 2020). Blockchain is widely used in manufacturing companies to carry out traceability to determine the position of goods in the supply chain flow (Ahmed et al., 2022; Abeyratne & Monfared, 2016). The use of blockchain makes it easier for companies to convey the latest information to external partners to understand conditions within the company related to raw material supplies, production processes, and delivery of finished products to consumers (Jain et al., 2021; Queiroz & Wamba, 2019). Green supply chain management has become a concern for many countries in maintaining an environmentally friendly environment (Famiyeh et al., 2018). Green supply chain management aims to reduce the environmental impact of the company's production or service processes (Laari et al., 2018). Companies try to minimize the environmental impact during the supply chain process, starting

with the information the company obtains regarding customer requests and ending with the company's ability to fulfill these requests according to predetermined orders (Latunreng & Nasirin, 2019). Companies focus on the environment by implementing environmentally friendly programs in production, distribution, inventory control, efficient use of raw materials, and administrative management (Fantazy et al., 2018). The integration of green practices needs to be applied throughout the company's supply chain, starting from the source of raw materials to the delivery of finished products to customers. Green practices in a company's supply chain are a strategic step in increasing competitiveness (Sahoo & Vijayvargy, 2021). Green supply chain management is important for companies to use raw materials efficiently with minimum impact on the company's environment (Kouhizadeh & Sarkis, 2022). Companies must focus on aspects of green supply management to maintain performance and become the first choice for customers (Allahham et al., 2024). In the raw material procurement stage, the company has chosen suppliers who pay attention to the green environment (Tarigan et al., 2020). Supplier companies are repeatedly informed about the use of materials that are dangerous or have the potential to damage the environment (Wong et al., 2015). Socialization and communication are built with suppliers to continue providing safer and environmentally friendly products (Novijanti et al., 2023). Currently, hotels as companies have begun to implement green supply chain management practices in response to customer demand for environmentally friendly services created through environmentally sustainable practices and in response to regulations (Basana et al., 2022). These practices require that manufacturing companies work with suppliers and customers to improve environmental sustainability (Sarkis et al., 2020). Implementing Green supply chain management practices will result in better environmental performance, measured through reduced air and waste emissions (Zhang et al., 2022). Manufacturing companies need to maintain environmental sustainability, impacting market share and profitability. Customers and government entities have begun to demand that processes, products, and services are environmentally friendly (Allaham et al., 2024). This condition is important for identifying and implementing environmental sustainability practices that extend throughout the supply chain (Basuki et al., 2023).

Global supply chain relationships have been influenced by economic globalization, so they face many challenges (Sahoo & Vijayvargy, 2021). The internal and external environments companies face continues to change slowly, enabling companies to meet growing needs (Sarkis et al., 2020). Consumer needs are always changing, and environmental uncertainty and surviving in a tight market competition environment require companies to collaborate with external partners (Siagian et al., 2023). Manufacturing companies must build trust in the supply chain, which is urgent and must be solved jointly with suppliers and customers (Tarigan et al., 2019). Trust in external partners is important in the supply chain to maintain competitiveness as a form of mutual interest (Eidizadeh et al., 2020). When partners in the supply chain face problems, sharing information and experiences between partners can be resolved quickly and accurately. Partners with a high level of trust can reduce coordination costs and increase knowledge sharing and information flow between collaborating companies (Hartono et al., 2023). Trust in the supply chain helps companies build flexibility, increasing their ability to face uncertainty and respond quickly to form core competitive advantages and meet market needs more flexibly and focused (Baah et al., 2022). Supply chain flexibility means that the supply chain built by a company can immediately respond to customer needs (Latunreng & Nasirin, 2019). Supply chain flexibility can resolve conflicts quickly during strategic decision-making and increase responsiveness and flexibility to environmental changes to deal with unexpected situations, avoid delivery delays and customer dissatisfaction, respond quickly to consumer requests with other companies in the supply chain, and maintain inventory levels that can be controlled (Manders et al., 2017). The company's ability to respond to environmental changes and provide customer-oriented products and services is a distinct advantage (Allaham et al., 2024). Companies can build supply chain flexibility to take advantage of advantages with partners and reduce risks. Building supply chain flexibility can also help companies increase efficiency and competitiveness in a changing technological environment, supply chain flexibility can provide products and services tailored to customers (Delic & Eyers, 2020; Novijanti et al., 2023). Green supply chain management is an integrated approach that can help companies develop strategies to generate increased profits (Wong et al., 2015; Sahoo & Vijayvargy, 2021). Green supply chain management practices must be implemented with environmental management systems to increase competitiveness (Zhang et al., 2022). Companies can adopt green supply chain practices by identifying raw materials from suppliers that are environmentally friendly for the company (Xu et al., 2017).

Based on the explanation above, the research can be determined with the following research objectives: First, to find out the magnitude of the influence of blockchain technology on green supply chain management, supply chain flexibility, and green supply practices in the environmentally friendly manufacturing industry. Second, get the magnitude of the influence of green supply chain management on green supply chain practices and supply chain flexibility in the environmentally friendly manufacturing industry. Third, get the magnitude of the influence of green supply chain practices on supply chain flexibility. Finally, the fourth found the magnitude of the influence of blockchain technology, green supply chain management, green supply chain practices, and supply chain flexibility on green supply chain performance in the environmentally friendly manufacturing industry.

2. Literature Review

2.1. Blockchain technology

Blockchain technology (BT) is a process of storing data, authenticating, and encrypting transactions along the supply chain, which are formed into blocks that can potentially benefit companies (Brau et al., 2023). Blockchain technology is

characterized by transparency, which allows the parties involved to access data that has been authenticated and becomes a reference for all components in the supply chain network (Ahmed et al., 2022; Jain et al., 2021). These properties provide data confidentiality, ensure secure transactions, and prevent information alteration (Pattanayak et al., 2024). Blockchain technology can share information with transactions accurately, reliably, and consistently (Tanwar et al., 2020). The blockchain's ability to record and share transaction records among all network nodes improves SCM performance (Choi, 2021). Dutta et al. (2020) emphasize that once an entry is created in a blockchain, the information is stored in blocks and cannot be edited without changing previous entries. This feature ensures safe and transparent business operations and builds trust relationships between stakeholders (Abeyratne & Monfared, 2016; Kshetri, 2017). Blockchain technology enables transparency in business and manufacturing in production forecasting and supply chain planning activities (Ghode et al., 2020; Tanwar et al., 2020). Blockchain is an electronic database that can be shared with partners as information to track every transaction on the network (Bag et al., 2021; Helo & Hao, 2019).

Esmaeilian et al. (2020) emphasize the ability of blockchain to monitor products at various stages of the supply chain. Blockchain technology allows companies to have quality data that can be used for efficient tracking and monitoring (Kang et al., 2023; Lohmer & Lasch, 2020). Blockchain adoption also supports responsible sourcing and compliance with environmental standards, improving traceability and transparency in sustainable supply chains (Yadav & Singh, 2020; Queiroz & Wamba, 2019). Blockchain technology can provide significant financial savings for a company or industry while supporting sustainability (Kouhizadeh & Sarkis, 2021; Wang et al., 2019). Immutability in blockchain ensures information security and helps increase trust in transactions throughout the supply chain (Rejeb et al., 2020; Meidute-Kavaliauskiene et al., 2021). It also fosters trust and integrity by recording all information from production to sales (Yadav & Singh, 2020). The indicator items used to measure the blockchain technology variables adopted are Immutability and Encryption, Improved Risk Management, Reduced Transaction Costs, and Transparency (Dutta et al., 2020; Abeyratne & Monfared, 2016; Ghode et al., 2020; Kshetri, 2017; Kamble et al. al., 2019).

2.2. Supply chain flexibility

Supply chain flexibility is a critical aspect of strategic supply chain management that allows companies to gain a competitive advantage (Baah et al., 2021). Supply chain flexibility is important in quickly resolving conflicts during strategic decision-making and increasing responsiveness and agility to deal with unexpected situations and environmental changes in product demand and delivery (Fischer et al., 2016; Meidute-Kavaliauskiene et al., 2021). By building supply chain flexibility, companies can better respond to customer requests, avoid delivery delays, and maintain controllable inventory levels because customers consider the company to have adequate capabilities (Famiyeh et al., 2018). Supply chain flexibility allows companies to adapt to changes in the technological environment and offer products and services tailored to customers, increasing efficiency and competitiveness (Delic & Eyers, 2020; Basana et al., 2023). Flexibility also allows companies to respond quickly to disruptions and changes in the supply chain, reducing uncertainty and mitigating risk (Liao, 2020; Katsaliaki et al., 2021). For a company to achieve goals, it is necessary to assess its ability to respond to unexpected changes and evaluate the company's level of supply chain flexibility (Gupta et al., 2019). Supply chain flexibility covers various dimensions, from inbound logistics to customer-oriented practices (Fischer et al., 2016). In addition, it involves synchronizing information systems and business processes of supply chain partners to meet customer demands (Gupta et al., 2019). Supply chain design also plays an important role in determining flexibility and ease of reconfiguration for uniformity, mobility, and range (Latunreng & Nasirin, 2019). Supply chain flexibility can be dynamic and continue to develop with significant implications for improving company performance and competitiveness (Liao, 2020).

2.3. Green supply chain management

Green supply chain management (GSCM) is an important aspect of supply chain management that involves the integration of environmental concerns into inter-company practices throughout the product life cycle (Sahoo & Vijayvargy, 2021). Green supply chain management is useful for protecting the environment by applying environmental management principles to the entire series of activities involved in the supply chain, including design, procurement, manufacturing, assembly, packaging, logistics, and distribution (Famiyeh et al., 2018). Green supply chain management is important for companies to achieve profit and market share goals while minimizing their environmental impact and increasing ecological efficiency (Bag et al., 2021).

Green supply chain management practices involve a combination of green purchasing, green manufacturing/materials management, green distribution/marketing, and reverse logistics (Wong et al., 2015; Siagian et al., 2023). The integration of environmental thinking in the supply chain management process ensures that environmental concerns are considered in material purchasing, energy consumption, waste discharge, reduction in air emissions, reduction in waste, product design, reduction in environmental impacts and risks to the general public, and end of product life cycle management. (Fantazy et al., 2018). Additionally, the importance of green supply chain management has increased in response to customer demand for environmentally sustainable products and services and government environmental regulations. A strategic approach for companies that want to improve environmental performance along the supply chain by actively involving external partners (Laari et al., 2018). The indicators determined to measure green supply chain management adopted by research are internal

environmental management, green purchasing, environmental performance, economic performance, and operational performance.

2.4. Green supply chain practices

Green supply chain practices (GSCP) play an important role in reducing the environmental impact of supply chain processes in an inter-company role (Sahoo & Vijayvargy, 2021). Supply chain practice is an activity controlled by a company from raw material procurement to product delivery, resulting in increased company performance and competitiveness (Tarigan et al., 2021). Implementing green supply chain practices by carrying out green purchasing involves supplier involvement in providing environmentally friendly raw materials (Famiyeh et al., 2018). Green purchasing includes integrating policies, programs, and processes supporting environmentally friendly procurement practices (Fantazy et al., 2018). Stakeholder pressure arising from suppliers, customers, and society often impels the adoption of green supply chain practices (Wong et al., 2015). Increasing awareness about environmental responsibility places significant importance on green supply chain practices for sustainable companies (Siagian et al., 2023).

2.5. Green supply chain performance

Green supply chain performance (GSCP) is an important aspect in evaluating the success of environmentally conscious supply chain practices. Green supply chain performance in a company is seen from the company's ability to operate the green supply chain efficiently and effectively compared to other companies (Baah et al., 2021). Green supply chain performance is achieved through two criteria: regulation and environmental performance. Regulations become business compliance in following established environmental policies and performance measurements to manage the environment with environmentally friendly processes and products. Environmental performance in businesses by paying attention to energy/resource consumption, emissions, and waste/disposal reduction (Famiyeh et al., 2018). Implementing green supply chain performance in companies is related to operational performance to improve product development, process efficiency, and on-time delivery (Tarigan et al., 2019). The practice carried out by companies is to evaluate performance from environmental impact aspects such as reducing used goods/waste, improving quality, delivery efficiency, and capacity utilization (Fantazy et al., 2018). Companies involved in logistics activities have also adopted green supply chain performance practices, emphasizing the importance of implementing environmentally conscious practices throughout the supply chain (Tarigan et al., 2020). This effect includes a positive impact on environmental performance, economic performance, and operational performance (Basuki et al., 2023). These impacts involve reductions in air, wastewater, and solid waste emissions and improvements in product delivery, inventory management, product quality, and capacity utilization. However, green supply chain performance can also incur additional costs, such as investment in environmentally friendly materials and increased operational and training costs (Basana et al., 2022). Implementing green supply chain performance plays a significant role in a company's environmental, economic, and operational success (Novijanti et al., 2023).

2.6. Relationships between research concepts

2.6.1. The relationship between blockchain technology and green supply chain management

Green supply chains driven by blockchain technology, the Internet of Things, artificial intelligence, and predictive analysis can drastically increase the integration and improvement of green practices in the supply chain process (Bag et al., 2021). Blockchain technology is closely related to the supply chain in utilizing technology together so that blockchain can become part of the supply chain in building competitiveness (Brau et al., 2023; Agi & Jha, 2022). The blockchain that has been implemented in manufacturing companies can provide traceability, and by automating business processes in real-time, it reduces the use of materials that have an impact on the environment (Ahmed et al., 2022; Wang et al., 2019). The use of adequate information technology on the blockchain can enable companies to directly meet customer expectations through applications with real-time information (Rejeb et al., 2020; Sheel & Nath, 2019). Blockchain technology provides a better economic and technological solution because it involves having a decentralized database and can be used as a form of green industry (Esmaeilian et al., 2020). Blockchain-based digital supply chains enable information to be shared across the value chain securely, reliably, and trusted (Mubarik et al., 2020; Kshetri, 2017). A supply chain based on a blockchain system is more connected, transparent, and quickly determined by the company's users' ability to better understand the technology (Kamble et al., 2019; Kouhizadeh & Sarkis, 2022). The supply chain uses technology to connect companies, customers, suppliers, and other stakeholders in a blockchain-use area (Jain et al., 2021; Wu et al., 2023). Such networks foster new levels of collaboration, connect more directly with customers, capture new markets quickly, and build and develop new offerings quickly (Pattanayak et al., 2024). Based on the explanation of the relationship between concepts, the first hypothesis can be determined.

H_1: *Blockchain technology influences green supply chain management.*

2.6.2. The relationship between blockchain technology and green supply chain practices

Blockchain technology has the property of managing unaltered company records and increasing company awareness so that it is easy to track (Pattanayak et al., 2024; Wu et al., 2023). Kuo et al. (2017) discussed the role of blockchain technology in the flow of corporate records and increasing corporate awareness. This is possible because data modifications are easily identified in blockchain technology, which works in blockchain-based logistics monitoring systems that perform several product visibility functions throughout the supply chain stages (Helo & Hao, 2019). Blockchain technology provides data management that may resist hacking and cannot be manipulated (Saberi et al., 2019). Blockchain-based supply chains enable information to be shared across the value chain safely, reliably, and reliably (Mubarik et al., 2020). Blockchain has created new trends in productivity by changing key business processes and increasing the internal and external integration of manufacturing companies (Lohmer & Lasch, 2020). An efficient blockchain technology structure can replace operations with automation, so many businesses are adopting it (Mubarik et al., 2019). Businesses must reevaluate their strategic supply chain strategies to implement digital supply networks powered by blockchain technology and increase their competitiveness in a disruptive technology environment that will synchronize the flow of talent, finance, information, and physical goods. (Kouhizadeh & Sarkis, 2021; Yadav and Singh, 2020). When the relationship between concepts is explained, the second hypothesis can be ascertained.

H_2: *Blockchain technology influences green supply chain practices.*

2.6.3. The relationship between blockchain technology and supply chain flexibility

Blockchain technology in supply chains must consider customer awareness of the tracking and costs of adopting blockchain technology (Wu et al., 2023). Blockchain technology in the supply chain can provide efforts to produce quality data, thereby making companies more flexible (Kang et al., 2023; Wang et al., 2019). Partnerships and information transparency between businesses can help managers understand whether personal relationships can be replaced by the information exchange provided by blockchain technology (Kummer et al., 2020). Blockchain technology enables secure data exchange in a distributed manner, improving companies' supply chain operations (Ghode et al., 2020). Blockchain technology impacts supply chain objectives by increasing flexibility (Kshetri, 2018). Building supply chain flexibility can enable companies to effectively deal with supply chain disruptions and changes in demand (Fischer et al., 2016). Blockchain technology can also help companies enable real-time data exchange within the network, which helps companies respond flexibly and resiliently when uncertainty occurs (Lohmer & Lasch, 2020; Sheel & Nath, 2019). Flexible and elastic response is an important factor for companies to build supply chain flexibility, and information transparency and blockchain security are expected to play a positive role in encouraging companies to build supply chain flexibility (Gupta et al., 2019). Blockchain technology can increase supply chain resilience (Dubey et al., 2020; Wu et al., 2023) and guarantee companies build supply chain flexibility (Sheel & Nath, 2019). The role of supply chain flexibility and information sharing is to improve competitive position (Queiroz & Wamba, 2019). Companies must share information with other parties in the supply chain to have flexibility in the supply chain (Meidute-Kavaliauskiene et al., 2021; Liao, 2020). The third hypothesis can be determined based on the explanation of the relationship between concepts.

H_3: *Blockchain technology influences supply chain flexibility.*

2.6.4. The relationship between blockchain technology and green supply chain performances

Digitization of supply chains with blockchain technology results in secure transactions, increased transparency, and product tracking (Sheel & Nath, 2019). The use of blockchain technology results in a reduction in process costs in the supply chain flow, which can have an impact on increasing supply chain performance (Queiroz & Wamba, 2019). The benefits of adopting blockchain technology include increased accountability and auditability (Kshetri, 2018; Yadav & Singh, 2020), fraud prevention (Xu et al., 2017), privacy, cyber security, and protection and improvement of financing processes (Kshetri, 2017). Blockchain technology in companies impacts transparent supply chain operations (Dubey et al., 2020). The level of trust offered by a supply chain supported by blockchain technology was an important element in developing relationships to improve supply chain sustainability performance goals (Agi & Jha, 2022). Blockchain technology impacts supply chain performance by providing automation, visibility, and reliable data (Pattanayak et al., 2024). Blockchain technology digitally integrates several stakeholders by facilitating supply chains that are useful in product tracking, transaction settlement, and process automation (Wang et al., 2019). Information integration is one form of ability to adopt blockchain technology (Wu et al., 2023). Green supply chain performances provided by blockchain technology are very secure and prevent unauthorized access to information in the database (Xu et al., 2017). Blockchain technology enables high levels of green supply chain performance that integrates customer, supplier, and customer information (Kamble et al., 2019; Yadav & Singh, 2020). Blockchain technology impacts supply chain objectives by reducing costs and improving quality, speed, dependability, and risk reduction (Kshetri, 2018). Similar integration of blockchain technology with other emerging technologies will reduce uncertainty and increase supply chain transparency, process integration, and tracking (Kang et al., 2023). The fourth hypothesis can be determined based on the explanation of the relationship between concepts.

H_4: *Blockchain technology influences green supply chain performances*.

2.6.5. The relationship between green supply chain management and green supply chain practices

Green supply chain management is now a strategic imperative based on customer demands for environmentally sustainable products that have been produced through processes designed and operated to increase environmental sustainability (Famiyeh et al., 2018). Adoption of green supply chain practices has an impact on improving environmental and economic performance. In manufacturing, strong relationships and close collaboration with suppliers result in improved environmental performance (Tarigan et al., 2021). Green purchasing and supply policies will likely improve environmental performance (Saberi et al., 2019). Green supply chain management practices were developed specifically to improve the environmental performance of manufacturing companies. Practices in green purchasing, collaboration with customers, eco-design, and investment recovery are designed to positively impact environmental performance (Wungkana et al., 2023; Tarigan et al., 2020). Implementing green supply chain practices and finding that green design positively impacts green supply chain management (Basana et al., 2022). The fifth hypothesis can be determined based on the explanation of the relationship between concepts.

H_5: *Green supply chain management influences adopting green supply chain practices.*

2.6.6. The relationship between green supply chain management and supply chain flexibility

Supply chain flexibility is important for companies in anticipating uncertainty caused by internal and external companies related to environmentally friendly products (Liao, 2020). The relationship between green supply chain management practices and economic and environmental performance. To implement green supply chain management practices, companies need their supply chain partners to improve environmental management capabilities by providing training programs with shared green systems (Basana et al., 2022). Supply chain flexibility allows companies to overcome uncertainty in a changing environment (Basana et al., 2023). Companies implementing green supply chain management can improve firm performance (Hartono et al., 2023). Based on the explanation of the relationship between concepts, the sixth hypothesis can be determined.

H_6: *Green supply chain management influences supply chain flexibility.*

2.6.7. The relationship between green supply chain management and green supply chain performances

In response to increasing global environmental awareness, green supply chain management has emerged as a concept that considers elements of sustainability and a combination of environmental thinking in intra- and inter-company management of upstream and downstream supply chains (Sahoo & Vijayvargy, 2021). Based on the competency approach, Zhang et al. (2022) stated that competitive resources come from strategy, structure, competence, innovation, and tangible and intangible resources. Green supply chain performances are a priority in the application based on respondents' assessments and contribute to the company's competitiveness (Fantazy et al., 2018). High-quality performance is critical to successful operations and can influence a company's competitive advantage. Supply chain design, planning, and operational decisions play an important role in determining the success or failure of a company (Wungkana et al., 2023). Implementing green supply chain management at a higher level is important in improving green supply chain performance. Laari et al. (2018) found that green supply chain management positively and significantly influences green supply chain performances. The seventh hypothesis can be determined based on the explanation of the relationship between concepts.

H_7: *Green supply chain management influences green supply chain performance.*

2.6.8. The relationship between green supply chain practices and supply chain flexibility

The adoption of green supply chain practices by manufacturing companies in green purchasing and internal environment management results in increased company flexibility by improving the ability to change the mix of products, change the volume of products, and create unique products for customers (Famiyeh et al., 2018). Green supply chain practices that are customer-oriented and operational performance in terms of flexibility, delivery, quality, and cost. Yang et al. (2015) also show that customer participation in green supply chain practices can help increase customer satisfaction with lower costs and higher product quality. Green supply chain practices improve operational performance in terms of cost, quality, and flexibility (Liao, 2020). The benefits of supply chain flexibility in terms of production and cost efficiency lie in the ability of manufacturing to implement it practically to facilitate the development of company strategies and guidelines for improving company performance (Delic and Eyers, 2020). Adopting supply chain practices by making changes to produce best practices impacts supply chain flexibility (Siagian et al., 2021). Based on the explanation of the relationship between concepts, the eighth hypothesis can be determined.

H_8: *Green supply chain practice influences supply chain flexibility.*

2.6.9. The relationship between green supply chain practices and performances

Green supply chain practices are steps for companies to take the initiative in protecting the environment by carrying out programs related to the environment to produce organizational performance in increasing the level of customer perceived value of products and service systems to meet particular (Fantazy et al., 2018). Green supply chain practices include externally

oriented practices related to the environment by involving external partners. Green supply chain practices can be divided into monitoring the fulfillment of environmental requirements with the suppliers having complied with a code of ethics and environmental collaboration with the development of cooperative activities to overcome environmental problems. Green supply chains formed through collaborative practices with partners can impact supply chain performance (Baah et al., 2021). Green supply chain practices refer to sustainable activities and initiatives implemented independently within the company or involving external partners with environmental management programs (Siagian et al., 2021). Green supply chain performances cover several dimensions: environmental performance by reducing environmental impacts, economic performance by increasing company profits, and social performance in society (Hartono et al., 2023). Green supply chain practices positively impact quality, customer satisfaction, and efficiency (Tarigan et al., 2020). However, green supply chain practices have an impact on supply chain performance (Wungkana et al., 2023). Based on the explanation of the relationship between concepts, the ninth hypothesis can be determined.

H_9: *Green supply chain practice influences green supply chain performances.*

2.10. The relationship between supply chain flexibility and green supply chain performances

Supply chain flexibility has developed with manufacturing flexibility and extends the idea of change without trade-offs from individual companies to the entire supply chain to remain competitive in an increasingly complex business environment. Supply chain flexibility is a strategy for responding to fluctuating environmental changes without losing performance (Manders et al., 2017). A flexible supply chain allows the production process to produce new products to adapt to the market in the quantities needed and flexibility in the delivery process (Delic and Eyers, 2020). Supply chain flexibility cannot be limited only to the performance of a particular company but must also include other members of the supply chain. The dimensions of supply chain flexibility have different effects on supply chain performance, including financial and non-financial performance, such as time-based performance and customer satisfaction. Supply chain flexibility leads to customer satisfaction by being customer-oriented and minimizing inventory to reduce company costs (Siagian et al., 2021). Flexibility influences supply chain efficiency through delivery reliability, where reliability is explained as the company's ability to fulfill delivery obligations and delivery speed (Manders et al., 2017). The tenth hypothesis can be determined based on the explanation of the relationship between concepts.

H_{10}: *Supply chain flexibility influences green supply chain performance.*

The research model in Fig. 1 can be determined based on the explanation above.

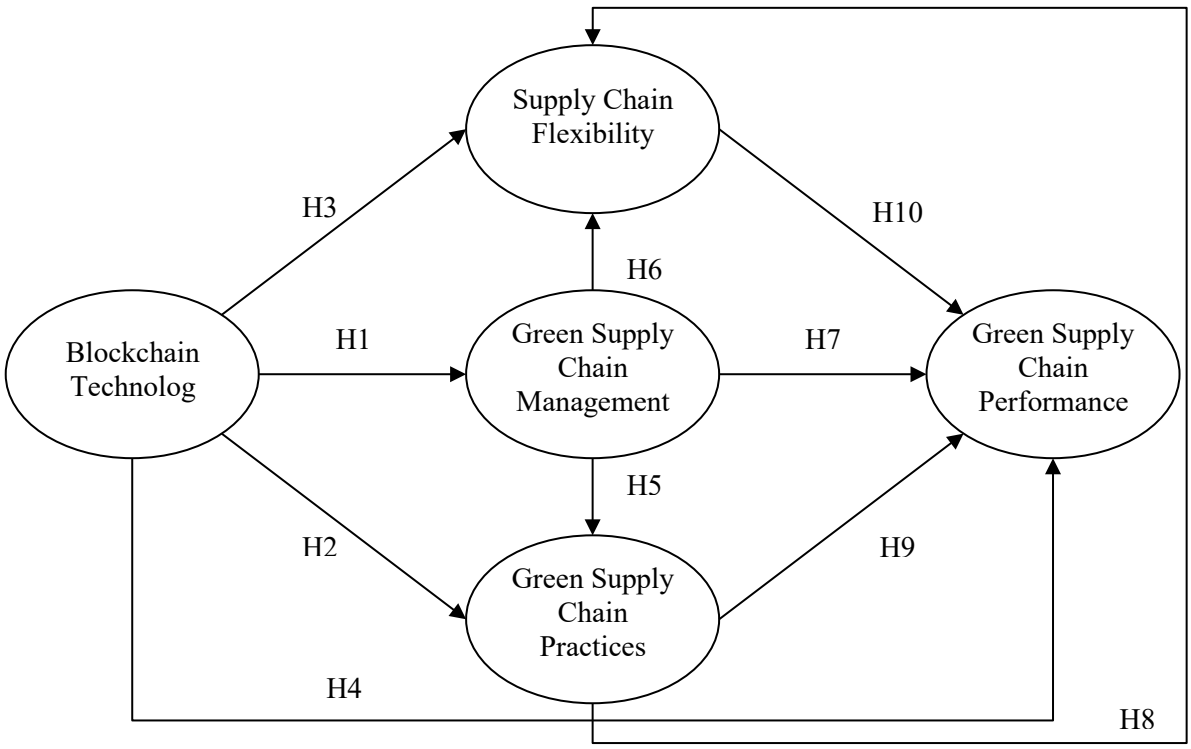

Fig. 1. Research Model

3. Research Methods

The research that has been determined is classified as causal quantitative research because it also examines the relationship between variables as a cause-and-effect relationship and uses quantitative data. Research from quantitative data itself aims to conclude the results obtained so that they can be useful for future research, which is called determining conclusions based on generalizations. This research will test the conceptual relationship between blockchain technology and green supply chain performance through supply chain flexibility, green supply chain management, and green supply chain practices. Eco-friendly manufacturing companies in Indonesia determined the population in the research. Based on the identification, the number of manufacturing companies studied was 511. The population used in this research is eco-friendly manufacturing companies involved in environmentally responsible business practices. A sample is a portion of the population that undergoes an identification stage to obtain a complete picture of the population from the sample. Sample selection in research was carried out through judgmental sampling by establishing certain criteria for certain objects or subjects. Based on the identification results, the characteristics of green manufacturing were obtained, namely the use of sustainable materials, energy efficiency, waste reduction, water conservation, emission control, implementation of a green supply chain, conducting product life cycle assessments, and innovation for more sustainable solutions. The research's target respondents are employees concerned with the environment, have work experience of at least one year, and have positions in the organizational structure as staff involved in the supply chain of eco-friendly manufacturing companies.

The measurement items are determined based on the research model, which is determined by operational definitions of research variables. Blockchain Technology (BT) is a decentralized technology implemented by manufacturing companies that pay attention to eco-friendliness. This research determines indicators in determining measurements on variables by adopting research, namely every transaction or data flow after being confirmed in the supply chain properly (BT1), the company can detect every transaction by operational reality (BT2), the company has data to anticipate payment risks late (BT3), able to reduce transaction costs (BT4), able to maintain data security properly and correctly (BT5), able to provide transparent data (BT6) and friendly to the environment (BT7). Green supply chain management (GSCM) is a strategy to reduce the environmental impact of the supply chain of eco-friendly manufacturing companies. The measurement items for green supply chain management are strategies in developing green supply chain management as a company priority through commitment and support from top management (GSCM1), the company implements green purchasing in procuring raw materials (GSCM2), the company tries to reduce consumption of materials that have an impact on the environment (GSCM3), Companies can increase economic value by using environmentally friendly materials (GSCM4) and reusable materials (GSCM5).

Variable green supply practice (GSP) is a best practice step companies use to preserve the environment by carrying out eco-friendly activities. The measurement items used for green supply chain practices are the company adopting the practice of using environmentally friendly materials for raw materials in the manufacturing process (GSP1), the company using environmentally friendly transportation modes (GSP2), the company distributing goods by paying attention to environmental impacts (GSP3), the company has an environmentally friendly warehouse (GSP4), the company has an environmentally friendly building (GSP5), the company has environmentally friendly packaging (GSP6) and the company involves the use of recycled products (GSP7). Supply chain flexibility (SCF) is the company's ability to respond to all forms of changes that occur both from internal and external sources. Supply chain flexibility is measured by the company's ability to respond to market changes (SCF1), the company can produce products that suit the market (SCF2), the company can build collaborative relationships with external partners (SCF3), the company can send products cost-effectively according to order changes (SCF4), the company can adjust the information system according to needs (SCF5) and the company can respond to changes in delivery schedules according to customer needs (SCF6). The green supply chain performance (GSCP) variable is defined as the company's ability to effectively and efficiently control the supply chain process in a certain period, which impacts the manufacturing environment. The measurement items determined are the company's ability to reduce air pollution (GSCP1), the company's ability to use energy efficiently (GSCP2), the company's ability to reduce waste (GSCP3), the company's ability to use environmentally friendly packaging (GSCP4), the company's ability to produce environmentally friendly products (GSCP5) and the company's ability to provide environmentally friendly labels on products (GSCP6). Data analysis used in the research was partial least squares with the SmartPLS program (Khan et al., 2019). Data management with PLS is divided into two models, namely the outer model and the inner model. The outer model test can be carried out using convergent validity and reliability tests. Validity aims to measure correlation with a load loading factor value greater than 0.700 and average variance extracted >0.500. Reliability uses Cronbach's Alpha or composite reliability with a minimum value of 0.700. The value of the inner model in testing research hypotheses can be seen from the t-statistics value ≥ 1.96 or p-value ≤ 0.05 for hypotheses that are declared accepted.

4. Data analysis and discussion

4.1. Descriptive Analysis and Discussion

The research was carried out by taking data from manufacturing companies that have adopted green by paying attention to eco-friendliness, which focuses on environmental friendliness. The distribution results are shown in Table 1 as a respondent profile.

Table 1
Respondent Profile

Item profile	Description	Sum	Percentage
Type of industry	Consumer product	140	27 %
	Electronic product	86	17 %
	Household products	71	14 %
	Industry product (chemical & energy)	95	19 %
	Packaging	43	8 %
	Textile and fashion	68	13 %
	Transportation	9	2 %
Long time been working at the company	1 years < - < 3 years	101	20 %
	3 years < - ≤ 6 years	247	48 %
	≥ 6 years	164	32 %
Position in the company	Owner	2	1 %
	Manager	296	57 %
	Supervisor	214	42 %
Number of Employees	< 100 officers	263	51 %
	≥ 100 officers	249	49 %
Department in working	Sales & Marketing	5	1 %
	Purchasing	4	1 %
	Production & Operational	94	18 %
	Planning Production Inventory Control	45	9 %
	Quality Control	130	25 %
	Supply Chain	101	20 %
	Research and Development	129	25 %
	Management	4	1 %
Type of Blockchain Technology	Amazon Managed Blockchain	56	11 %
	Consortium Blockchain	24	5 %
	Data Transparency	84	16 %
	Hybrid Blockchain	24	5 %
	IBM Blockchain	48	9 %
	Microsoft Azure Blockchain	42	8 %
	Private Blockchain	41	8 %
	Public Blockchain	45	9 %
	Smart Contracts	35	7 %
	Traceability	113	22 %

Based on the results of distributing questionnaires to manufacturing companies, it was found that the largest type of consumer product industry was 140 companies (27%). Customers directly use companies in this type of industry, so many customers emphasize that companies focus on green products that directly impact users' health. The profile of respondents who have work experience of more than three years is 411 respondents (80%), which shows that respondents have a good understanding of the green processes and programs that have been adopted and are ongoing to date. A study of the positions in the company found that there were 296 manager positions (57%), which stated that the company assigned duties and responsibilities for implementing the green supply chain to the manager position. The respondents were managers who could understand the details and concepts of implementing green in producing eco-friendly products. Meanwhile, company size is balanced between those with more than 100 employees and those with less. This condition shows the division for manufacturing companies that have adopted blockchain technology in company systems. A review of departments in working shows that the largest number of respondents in quality control was 130 respondents (25%), followed by the research and development department with 129 respondents (25%). The two divisions are closely related to the company's technology use because they are still relatively new, so they are always under the supervision of these two departments. The results of distributing questionnaires to eco-friendly companies by providing specified measurement items to obtain inner model tests by testing validity and reliability.

Table 2 shows that the average value for blockchain technology is 4.1387, with an average value for measurement items between 4.1055 – 4.2051. These results show that the company has adopted blockchain technology well based on its needs. The company has tried to use technology to provide environmental friendliness in the transaction process. As determined by the company, green supply chain management has an average value of 4.1723 and an average value of measurement items between 4.1660 and 4.1816. This condition shows that the company has established a strategy for collaborating with internal and external partners by paying attention to environmental conditions that impact the sustainability of the company's processes. The established green supply chain practice is a best practice step for preserving the environment by carrying out eco-friendly activities with a mean value of 4.2542 and a mean value of measurement items between 4.2168 – 4.3184. Green supply chain practices have been implemented well by manufacturing companies in Indonesia committed to being eco-friendly by paying attention to implementation throughout the supply chain. Supply chain flexibility is shown in Table 1, with a mean value of 4.2477 and measurement items having a mean of 4.2012 – 4.3086. The supply chain flexibility formed by the company has responded well to external partners. The company's ability to be flexible can continuously increase customer satisfaction and company performance. The last variable in green supply chain performance is the company's ability to effectively and efficiently control the supply chain process, with a mean value of 4.1846 and measurement items 4.1367 – 4.2188. This shows that manufacturing companies have achieved good performance in producing highly efficient and effective

environmentally friendly products. Increasing company performance in implementing green supply chains and good flexibility on an ongoing basis causes an increase in sustainable performance.

Table 2
Mean and outer model test

Research Items	Mean	Factor loading	Cronbach Alpha	Composite Reliability	AVE
Blockchain Technology (BT)	**4.1387**		0.910	0.929	0.650
BT1	4.1055	0.792			
BT2	4.1113	0.820			
BT3	4.1191	0.808			
BT4	4.1523	0.818			
BT5	4.1094	0.833			
BT6	4.2051	0.787			
BT7	4.1680	0.785			
Green supply chain management (GSCM)	**4.1723**		0.888	0.918	0.691
GSCM1	4.1660	0.828			
GSCM2	4.1621	0.818			
GSCM3	4.1816	0.846			
GSCM4	4.1738	0.830			
GSCM5	4.1777	0.833			
Green supply practice (GSP)	**4.2542**		0.896	0.918	0.616
GSP1	4.2539	0.812			
GSP2	4.2656	0.776			
GSP3	4.2324	0.811			
GSP4	4.2578	0.807			
GSP5	4.2344	0.809			
GSP6	4.2168	0.737			
GSP7	4.3184	0.738			
Supply chain flexibility (SCF)	**4.2477**		0.891	0.917	0.647
SCF1	4.2715	0.790			
SCF2	4.3086	0.810			
SCF3	4.2285	0.800			
SCF4	4.2070	0.792			
SCF5	4.2695	0.826			
SCF6	4.2012	0.808			
Green supply chain performance (GSCP)	**4.1846**		0.905	0.926	0.677
GSCP1	4.2188	0.786			
GSCP2	4.2031	0.785			
GSCP3	4.1934	0.838			
GSCP4	4.1738	0.854			
GSCP5	4.1816	0.844			
GSCP6	4.1367	0.829			

Based on Table 2, the lowest loading factor value for the blockchain technology variable was 0.785 for item BT7 (use of environmentally friendly technology), green supply chain management, and the lowest value was 0.818 for item GSCM2 (companies implement green purchasing in procuring raw materials), green supply chain practice with the lowest value on item GSP6 (the company has environmentally friendly product packaging) of 0.737, supply chain flexibility with the lowest value on item SCF1 (company's ability to respond to market changes) of 0.790, and finally on green supply chain performance the lowest value of 0.785 on the GSCP2 item (company's ability to use energy efficiently) of 0.773. The five variables with a loading factor value for each measurement item are above 0.700, so they meet the requirements for a high-validity test. Tests for reliability values on composite reliability and Cronbach alpha for research variables, respectively, are blockchain technology composite reliability 0.929 and Cronbach alpha 0.910; green supply chain management composite reliability 0.918 and Cronbach alpha 0.888; green supply chain practice with composite reliability 0.918 and Cronbach alpha 0.896; supply chain flexibility with composite reliability 0.917 and Cronbach alpha 0.891 and finally the green supply chain performance variable composite reliability 0.926 and Cronbach alpha 0.905. The reliability test results for all variables have met the requirements of being above 0.700 (Khan et al., 2019).

4.2. Inferential analysis and discussion

Testing of the outer and inner models has been fulfilled so that the results of research data processing can be used to answer all the research hypotheses shown in Fig. 2 and Table 3. Based on Fig. 2 and Table 3, it was found that the results of the research hypothesis obtained the magnitude of the influence between the research variables and the t-statistics or p-value. The first hypothesis is stated by stating that blockchain technology influences green supply chain management of 0.816 with a t-statistics value of 46.837 (>1.96) and a p-value of 0.000 (<0.050), so the hypothesis can be accepted. These results show that the blockchain technology used could detect every transaction by operational reality and can provide transparent data that can improve eco-friendly green supply chain management. Companies with green supply chain management can reduce the consumption of materials that impact the environment and increase economic value by using environmentally friendly materials. The research results support the results of previous research, which states that the implementation of blockchain technology affects green supply chain management (Bag et al., 2021; Ahmed et al., 2022; Wang et al., 2019; Esmaeilian et

al., 2020; Pattanayak et al., 2020; ., 2024). The second hypothesis obtained by blockchain technology influences green supply chain practices of 0.370 with a t-statistics value of 7.676 (>1.96) and a p-value of 0.000 (<0.050), so the hypothesis can be accepted. The company's blockchain technology can practically maintain data security well and detect every transaction by operational realities, providing an impact of 0.370 so that there is an increase in green supply chain practices by distributing goods with attention to environmental impacts and the company having environmentally friendly packaging. Research results have confirmed research results which state that blockchain technology affects improving green supply chain practices (Helo & Hao, 2019; Saberi et al., 2019; Lohmer & Lasch, 2020; Mubarik et al., 2019; Kouhizadeh & Sarkis, 2021; Yadav & Singh, 2020).

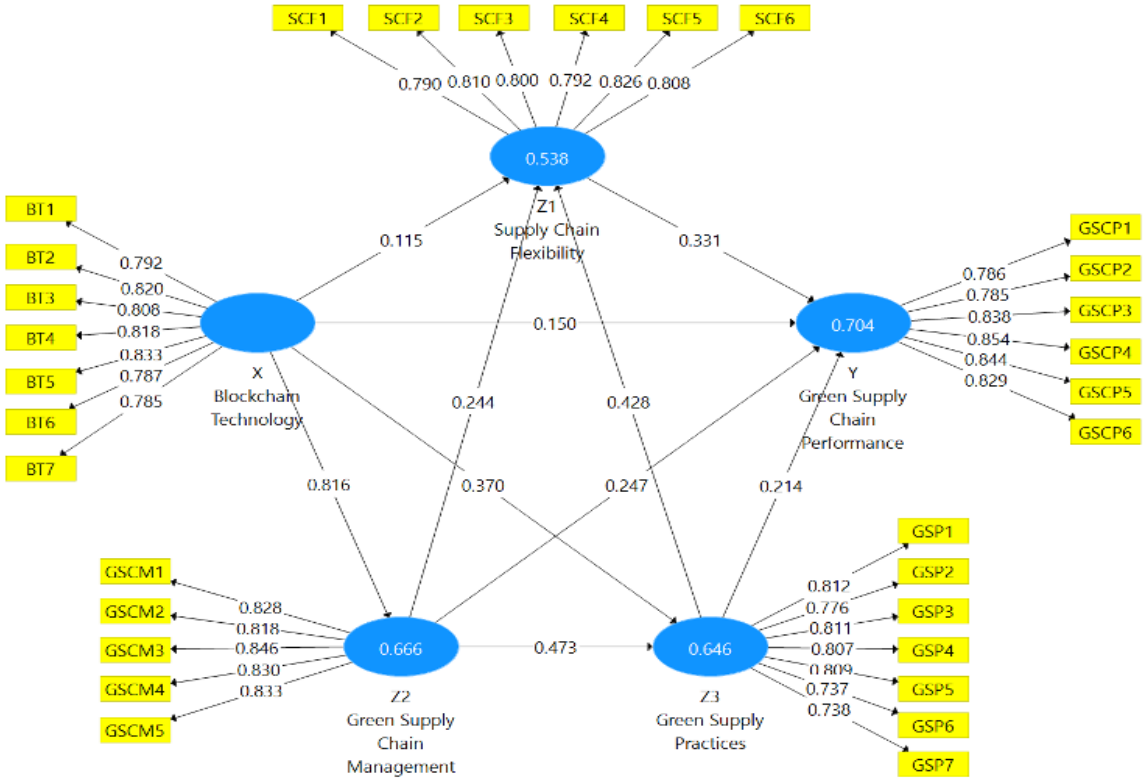

Fig. 2. The results of the factor loading

Table 3
Test the inner model hypothesis

Direct path coefficient	Original sample	T statistics	P-values
Blockchain Technology → Green Supply Chain Management (H1)	0.816	46.837	0.000
Blockchain Technology → Green Supply Practices (H2)	0.370	7.676	0.000
Blockchain Technology → Supply Chain Flexibility (H3)	0.115	1.899	0.058
Blockchain Technology → Green Supply Chain Performance (H4)	0.150	2.488	0.013
Green Supply Chain Management → Green Supply Practices (H5)	0.473	9.635	0.000
Green Supply Chain Management → Supply Chain Flexibility (H6)	0.244	3.869	0.000
Green Supply Chain Management → Green Supply Chain Performance (H7)	0.247	4.243	0.000
Green Supply Practices → Supply Chain Flexibility (H8)	0.428	7.387	0.000
Green Supply Practices → Green Supply Chain Performance (H9)	0.211	4.124	0.000
Supply Chain Flexibility → Green Supply Chain Performance (H10)	0.331	7.012	0.000

Blockchain technology has an effect of 0.115 on supply chain flexibility as the third hypothesis with a t-statistics value of 1.899 (>1.65) and a p-value of 0.058 (<0.100), so the hypothesis can be accepted with a significance level of 10%. Blockchain technology, which is formed in companies that are able to detect every transaction by operational realities, maintain data security properly and correctly, and have data to anticipate the risk of late payments, can produce supply chain flexibility with external partners. The company's increase in supply chain flexibility can be seen by increasing its quick response to market changes and building collaborative relationships with external partners. The research results support research results which state that blockchain technology affects supply chain flexibility (Wu et al., 2023; Kang et al., 2023; Wang et al., 2019; Kshetri, 2018; Fischer et al., 2016; Lohmer & Lasch, 2020; Sheel & Nath, 2019; Gupta et al., 2019; The fourth hypothesis is that blockchain technology has an effect on green supply chain performances of 0.150 with a t-statistics value of 2.488 (>1.96) and a p-value of 0.013 (<0.05), so the hypothesis can be accepted. Blockchain technology is defined by the company's ability

to have data to anticipate the risk of late payments, every transaction or data flow after being properly confirmed and being able to reduce transaction costs has an impact on increasing green supply chain performance with the company's ability to use energy efficiently. The research results confirm research results which state that blockchain technology affects green supply chain performances (Queiroz & Wamba, 2019; Yadav & Singh, 2020; Dubey et al., 2020; Agi & Jha, 2022; Pattanayak et al., 2024; Kamble et al., 2019).

Green supply chain management affects the adoption of green supply chain practices by 0.473, which is determined as the fifth hypothesis with a t-statistics value of 9.635 (>1.96) and a p-value of 0.000 (<0.05), so the hypothesis is acceptable. The company's ability to adopt green supply chain management with the commitment and support of top management in implementing green, the company implementing green purchasing in procuring raw materials, and the company trying to reduce consumption of materials that impact the environment has an impact on green supply chain practices. The company's best practice steps are to preserve the environment by carrying out eco-friendly activities and increasing activities by adopting environmentally friendly materials for raw materials in manufacturing and using recycled products. The research results have confirmed research results which state that green supply chain management influences the speed of adopting green supply chain practices (Famiyeh et al., 2018; Tarigan et al., 2021; Saberi et al., 2019; Wungkana et al., 2023; Basana et al., 2022; Tarigan et al., 2020). The sixth hypothesis is that green supply chain management influences supply chain flexibility of 0.244 with a t-statistics value of 3.869 (>1.96) and a p-value of 0.000 (<0.05), so the hypothesis can be accepted. Green supply chain management is formed in companies trying to reduce the consumption of materials that impact the environment. The company can use reusable materials, which influences supply chain flexibility. The company can respond to market changes with environmentally friendly products, and the company can respond to schedule changes. Delivery according to customer requirements. The results support previous research, stating that green supply chain management affects supply chain flexibility (Liao, 2020; Basana et al., 2022; Hartono et al., 2023).

Green supply chain management has an effect of 0.247 on green supply chain performances as the seventh hypothesis with a t-statistics value of 4.243 (>1.96) and a p-value of 0.000 (<0.05), so the hypothesis can be accepted. Green supply chain management is a commitment of the company's top management, which is described by the company being able to increase economic value by using environmentally friendly materials and trying to reduce the consumption of materials that have an impact on the environment, which has an impact on increasing green supply chain performance by increasing the company's ability to reduce air pollution and the company's ability to reduce waste. The results of this research are by research results which state that green supply chain management influences green supply chain performances (Sahoo & Vijayvargy, 2021; Fantazy et al., 2018; Wungkana et al., 2023; Laari et al., 2018). The eighth hypothesis determined by green supply chain practice affects supply chain flexibility of 0.428 as the eighth hypothesis with a t-statistics value of 7.387 (>1.96) and a p-value of 0.000 (<0.05), so the hypothesis can be accepted. The company's ability to respond to market changes, build collaborative relationships with external partners, and adapt information systems according to needs as supply chain flexibility measurement items can improve green supply chain practices. This condition is reflected in the increase in companies adopting the practice of using environmentally friendly materials for raw materials in the manufacturing process, companies with environmentally friendly buildings, and companies with environmentally friendly packaging. The results of this research confirm the results of previous research, which stated that green supply chain practices influence supply chain flexibility (Famiyeh et al., 2018; Yang et al., 2015; Liao, 2020; Delic and Eyers, 2020; Siagian et al., 2021).

The ninth hypothesis determined by green supply chain practices influences green supply chain performances of 0.214 with a t-statistics value of 4.124 (>1.96) and a p-value of 0.000 (<0.05), so the hypothesis can be accepted. The company's ability to adopt best practices is to have environmentally friendly buildings. Companies using environmentally friendly modes of transportation, companies with environmentally friendly packaging, and companies using recycled products can improve green supply chain performance by reducing waste and producing environmentally friendly products. The research results support the results of previous research, which stated that green supply chain practices influence green supply chain performances (Fantazy et al., 2018; Baah et al., 2021; Tarigan et al., 2020; Hartono et al., 2023; Wungkana et al., 2023). The final, tenth hypothesis states that supply chain flexibility influences green supply chain performances of 0.331 with a t-statistics value of 7.012 (>1.96) and a p-value of 0.000 (<0.05), so the hypothesis can be accepted. Companies can increase flexibility in building collaborative relationships with external partners, sending products cost-effectively according to changes in orders, and responding to changes in delivery schedules according to customer needs can significantly impact green supply chain performances. This condition can be seen from the company's ability to reduce air pollution and waste and environmentally friendly packaging and products. Manufacturing companies in Indonesia have committed to implementing eco-friendly production processes by regulations set by regional and central governments. The research results have confirmed the results of previous research, which stated that supply chain flexibility influences green supply chain performances (Manders et al., 2017; Delic and Eyers, 2020; Siagian et al., 2021).

Many manufacturing companies in Indonesia have used adequate technology to carry out production processes and have collaborated with supply chain partners to produce eco-friendly products. The company has maintained the production process to maintain sustainable performance. Manufacturing companies have formed supply chain integration with external partners to involve partners in committing to producing environmentally friendly programs. This research provides insight for the government to remain committed and continuously monitor manufacturing companies so that they comply with the regulations

and rules that have been set. Green practice for manufacturing companies is difficult, but many efficient and effective technologies are currently used to utilize environmentally friendly energy. Many manufacturing companies are also committed to producing environmentally friendly products to respond to customer pressure. The theoretical contribution of the research is to enrich theories about the green environment and green supply chain management, in addition to applying them to the manufacturing industry related to blockchain technology.

5. Conclusion

Public awareness and consumer preferences for environmentally friendly products continue to increase. Consumers can make purchasing decisions based on their products' sustainability and environmental impact. These changes in consumer behavior are putting pressure on manufacturing companies to adopt green practices and invest in environmentally friendly manufacturing facilities. The company focuses on the environment by implementing environmentally friendly programs in the supply chain flow, namely production, distribution, inventory control, and efficient use of raw materials. Companies can use technology to provide fast and real-time information. Research that has been carried out on manufacturing companies in Indonesia, based on the results of analysis and discussion, has resulted in several research conclusions. Firstly, blockchain technology is established in manufacturing companies in Indonesia, which can detect every transaction by operational realities and provide transparent data that can improve eco-friendly green supply chain management, supply chain flexibility, and green supply chain performance. Green supply chain management, which has become a commitment from top management to be adopted by reducing material consumption, has an impact on the environment, and the company is able to use reusable materials, which have an impact on green supply practices, supply chain flexibility, and green supply chain performance. Green supply practices in manufacturing companies in Indonesia by adopting best practices through environmentally friendly buildings. Using environmentally friendly modes of transportation and packaging, as well as involving the use of recycled products, can improve green supply chain performance. Supply chain flexibility that has been running in manufacturing companies with collaborative relationships with external partners shipping products cost-effectively according to changes in orders and responding to changes in delivery schedules according to customer needs can significantly impact green supply chain performances. The practical contribution that will be achieved will enlighten middle and top management on the importance of maintaining environmental harmony to adequately support the sustainability of company performance.

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